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January 31, 1935

Zinc Base Die Castings

Object

To determine the suitability of zinc base die castings for Ordnance requirements.

Conclusions

The most significant changes that occur upon aging zinc die castings are in impact values and length.

The aluminum-containing zinc-base die-casting with no copper showed the least change in impact and dimensions upon artificial aging at this arsenal.

As the copper content increases, the changes that occur on aging increase.

The presence of Cd as an impurity accelerates aging causing marked changes in dimensions to occur.

Zinc base die cast bouchons under observation by other arsenals contain too much Cd as an impurity, and therefore are liable to excessive change in dimensions and loss of ductility. The impurity may have diffused into the zinc from the electro plated Cd used for protective purposes.

Zinc base die casting containing Cu, even if of proper purity are not as suitable for Ordnance purposes as those without Cu.

U. S. Army Specification 57-93A is old and no longer suitable for procuring die castings. Specification WXS8 has been suggested as suitable for procuring zinc base die castings suitable for Ordnance purposes.

Zinc base die casting containing 3.5/4.3% Al, 0.03/0.08% Mg appear suitable for ordnance purposes requiring many duplicate parts whose dimensional tolerances are nominal, and whose dimensions are not large.

The dichromate film is a suitable corrosion prevention means. Ni plate is not satisfactory for long time use. Cd plate must be used with care if used at all.

Introduction

Though zinc base die castings have been used over a considerable number of years it is only recently that much valuable metallurgical information has become available due primarily to the activities of the American Society for Testing Materials (A.S.T.M.)

Tin-lead compositions were originally used in die casting but an outgrowth was an alloy containing 3% Cu 6% Sn 0.5% Al and 90.5% Zn. This alloy has relatively little strength.

It was discovered that aluminum containing

zinc base die castings, usually with copper also, were much stronger, had greater fluidity and were free of hot shortness which made casting easier. However, most of the commercial alloys of this composition when used in the tropics under conditions of moist heat disintegrated rapidly. The New Jersey Zinc Company studied the failures and later together with the A.S.T.M. has developed alloys resistant to moist heat.

Die cast metals are of very great interest to the Ordnance Department because of the possibility of cheap mass production of intricate shapes to close tolerances. Zinc base alloys are but one of the alloys available. Aluminum base alloys constitute another class. More recently, die-pressing of hot brasses has come on the market to meet competition from die-casting. These developments are of recent origin, have great potentialities and should therefore be followed close by.

The development of zinc base die casting alloys is still underway but commercial exploitation of newer discoveries will probably start to decrease from now on. The metallurgical literature dealing with this class of alloys is approaching voluminous proportions, especially in very recent years. Aluminum dissolves in zinc some 0.25% at room temperature and 0.85% at 335°C. The

solid solution is referred to as Alpha. Zinc dissolves in aluminum some 18% at room temperature, and this solid solution constitutes the delta phase. A eutectic is formed at some 6% Al at about 380°C between two constituents referred to as alpha and beta. At 256°C, the beta phase breaks down to alpha and delta.

Upon exposure to moisture, especially in the presence of heat intercrystalline corrosion occurs. It is the alpha phase and not delta which is oxidized. When beta decomposes, an enormous number of secondary grain boundaries are exposed to corrosion. The severity of this intercrystalline oxidation is affected by grain size and by impurities which may be present. Lead, cadmium and tin are powerful accelerators of the oxidation which occurs.

The results of development work to date are summarized in Table I "Commercial Specifications for Zinc Base Die Castings". Column 3 gives three specifications for that alloy which corresponds to Army Alloy C1 (Spec. 57-93A). The limits imposed in the newer specifications have been determined by careful research and are commercially satisfactory. Factors such as strength, stability, fluidity and castability were considered. Column 4 and 5 are descriptive of a relatively new alloy and its still newer modification. The use of A.S.T.M. alloy 23 is increasing and it is expected that it will eventually

COMMERCIAL SPECIFICATIONS FOR ZINC BASE DIE CASTINGS.

ARMY			PRESENT DAY ACCEPTABLE ALLOYS.							
Column	1	2	3			4			5	
Alloy	C1	C2	ASTM B86-33T Alloy XXI	SAE 921	N.J.Zn Co. Zamak 2	ASTM B86-33T Alloy XXIII	ASTM Preprint 183 1934 Alloy XXIII	SAE 903	N.J.Zn Co. Zamak 3	Zamak 3N Optional
Cu	$\frac{2.0}{4.0}$	$\frac{2.0}{3.0}$	$\frac{2.5}{3.5}$	$\frac{2.5}{3.5}$	$\frac{2.5}{3.5}$	0.10 mx	0.10 mx	0.10 mx	0.03 mx	0.03 mx
Al	$\frac{4.0}{6.0}$	$\frac{10.0}{12.0}$	$\frac{3.5}{4.5}$	$\frac{3.5}{4.5}$	$\frac{3.9}{4.3}$	$\frac{3.5}{4.5}$	$\frac{3.5}{4.5}$	$\frac{3.5}{4.5}$	$\frac{3.9}{4.3}$	$\frac{4.3}{3.9}$
Mg			$\frac{0.02}{0.10}$	$\frac{0.02}{0.12}$	$\frac{0.02}{0.05}$	$\frac{0.03}{0.08}$	$\frac{0.03}{0.08}$	$\frac{0.03}{0.08}$	$\frac{0.02}{0.05}$	$\frac{0.03}{0.06}$
Fe			0.10 mx	0.10 mx	0.075 mx	0.100 mx	0.100 mx	0.10 mx	0.075 mx	0.075 mx
Pb	.10 mx		0.007 mx	0.01 mx	0.004 mx	0.007 mx	0.007 mx	0.007 mx	0.004 mx	0.004 mx
Cd			0.005 mx	0.005 mx	0.004 mx	0.005 mx	0.005 mx	0.005 mx	0.004 mx	0.004 mx
Sn			0.005 mx	0.005 mx	0.001 mx	0.005 mx	0.005 mx	0.005 mx	0.001 mx	0.001 mx
Zn			remainder ³	rmdr.	rmdr.	rmdr. ³	rmdr. ³	rmdr.	rmdr.	rmdr.
Ni										$\frac{0.015}{0.05}$
Total other impurities	.40 ¹ mx	.40 ² mx		0.02 mx						

Recommended

Ingots

Grade A

Ingots

Grade B

1 includes Fe,Cd,Si. 2 includes Pb,Fe,Cd,Si. 3 special high grade zinc.

Grade A

Optional

TABLE II

Chemical Composition for Zinc Die Castings

Alloy Number	Zamak 2	Zamak 3	Zamak 5	*** A 5219	Bouchon
Specimen Number	2	1	1	1	
Element	Percent				
Al	3.98	4.08	3.71	4.24	4.97
Mg	.035	.033	.022	.033	
Cu	2.60	Nil	.93	Nil	3.80
Zn (diff.)	93.39	95.89	95.34	95.73	
Cd	Nil	Nil	Nil	Nil	.162
Fe	Trace*				.10
Ni	Nil	Nil	Nil	Trace*	
Sn	Nil	Nil	Nil	Nil	Nil*
Pb	Nil	Nil	Nil	Nil	
Pb	Trace*	Trace*		Trace*	Trace*

* Spectroscopic analysis

** " " also

*** This alloy corresponds to Zamak 3N Table I

be the most widely used alloy.

Test Material

The New Jersey Zinc Company and the Milwaukee Die Casting Company were requested to supply test material. The Milwaukee Die Casting Company refused to supply any gratis on account of economic conditions. The New Jersey Zinc Company supplied the Arsenal with 252 test specimens representative of 4 alloys, with and without various protective films. Considerable information was also given regarding the aging of the alloys. The alloys supplied were: Zamak 2, Zamak 3, Zamak 3-S (Stabilized to hasten contraction which occurs during 5 wks after casting) Zamak 5, A5219, (which is Zamak 3 with traces of Ni) Q1077, 78, 79, 80 (which were Zamak 2, 3, 5 and A5219 with dichromate film) and H2275, 76, 77 and 74 (which were these same alloys with 0.001" Ni plate). Zinc base die cast bouchons were supplied by Picatinny Arsenal.

Composition

Reports W.A349/12, 15, by A. Sloan, chemist, and 122/5, 6, by Lt. D. J. Crawford and 122/7 by S. Vigo, chemist, are summarized in Table II. Fig. 1 is indicative of spectrographic exam-

ination of the zinc base die cast bouchon.

Description of Tests

Fig 2 is descriptive of the test specimens used in development work. Test specimens A and C were used in the study at this Arsenal.

Bars were exposed for 10 days to dry heat at 95°C by being placed in paraffin in an oven kept at $95^{\circ} \pm 5^{\circ}\text{C}$. The changes that occur may be attributed to the breakdown of the Beta phase.

Bars were exposed for 10 and 20 days to wet steam by being held above water on a galvanized wire screen. The water was maintained at $95^{\circ} \pm 1^{\circ}\text{C}$ in a metallic container. The changes that occurred are due to the combined effect of breakdown of beta phase and intergranular corrosion.

Bars with surfaces protected with bright Ni plate and with dichromate film were subjected to the salt spray for 100 or 176 hour periods.

Other bars were mounted on a wooden frame and exposed to outdoor and indoor atmospheres. Tests of these are still under way.

Results.

Table III gives the results obtained from these studies. Each observation of tensile

properties is the average of 2 observations with the exception of "Wet 20 days" which was only 1 observation. These results are graphically shown in Fig. 3.

Zinc die castings are prone to have porous areas; it is customary to use 5 test bars to obtain representative data. The data presented therefore can only be taken as indicative of the properties to be obtained. It is evident that A5219 would not pass specifications.

On Table IV are listed the tensile properties of the plated test bars after exposure to salt spray. Fig. 4 shows the appearance of the bars after corrosion.

The zinc-base die-cast bouchon, when heated for 10 days in steam at 95°C was found to expand more than 0.0025 in. per in. Metallographic examination revealed fissuring parallel to surface, evidence of intergranular corrosion penetrating from surface, and no trace of Cd.

Discussion

It is noted that the most significant changes that occurred are in impact strength and length. The changes in tensile strength were relatively small and more or less uniform

TABLE IV

Corrosion of Zinc Base Die Castings

Effect of Salt Spray and of Method of Protection.

Plate	Zamak 2		Zamak 3		Zamak 5		A5219 (Zamak 3N)	
	T.S.	El	T.S.	El	T.S.	El	T.S.	El
	1000psi	%	1000psi	%	1000psi	%	1000psi	%
100 hrs. Synthetic Sea Salt*								
Dichromate	46.0	8.5	38.0	4.5	40.2	5.0	35.2	2.0
None	44.4	6.0	36.2	6.7	41.4	5.5	35.8	8.5
.001"Ni	41.8	2.0	34.4	1.5	39.2	2.	35.2	1.5
100 hrs. Synthetic Sea Salt & 76 hrs. 20% NaCl*								
Dichromate	48.8	3.5	36.6	8.0	41.8	8.0		
None	40.0	2.5	36.2	3.0	40.4	5.0		
.001"Ni	39.8	1.5	36.0	2.0	38.4	2.0		
Original Ave	46.9	6.8	37.5	6.8	41.2	5.5	36.9	6.3
Mx	47.6	8.5	37.6	7.0	41.6	5.5	38.6	8.5
Mn	46.2	5.0	37.4	6.5	40.8	5.5	35.2	4.0

* Properties of single specimens.

irrespective of the alloy composition. Ductility values were affected in a manner that would be expected from intergranular corrosion.

Upon dry anneal the high Cu alloy (Zamak 2) lost a large fraction of its ductility and expanded very considerably. The low Cu alloy (Zamak 5) behaved similarly though not to as great a degree. The alloy with no Cu (Zamak 3) actually increased in ductility upon dry anneal.

Because of this combined contraction and expansion in the early life of zinc die castings, intercomparison of data is not possible unless the age of the specimen is known. In advertising literature the data is usually taken on specimens aged for 6 months. What can be safely compared is the order of magnitude of the expansion of the different alloys. Thus it was found that Zamak 2 expanded 1×10^{-3} in. per in. after 10 days in steam at 95°C . This is usually considered the equivalent of 1 year's normal use in the tropics. The other alloys expanded around 1×10^{-4} in. per in.

Stability of Zinc base Die Casting

Data made available by the New Jersey Zinc Company concerning the changes that occur in properties of zinc die castings are shown on Figs. 5a, b, c. Zamak 2 is the strongest alloy but loses most markedly in impact and changes dimensions the

most. Zamak 5 also loses in impact and changes slightly. Zamak 3 does not lose in impact and changes least in dimensions. Zamak 3N shows evidence of increasing in impact value with age and not changing any more than Zamak 3 in dimensions.

Table V lists the only other other extensive unbiased stability data for A.S.T.M. alloy XXI (which corresponds to Zamak 2). As far as comparison is possible the data compares very satisfactorily with those given in Fig. 5.

All aluminum containing zinc-base die castings suffer a contraction immediately after casting. This contraction is of the order of magnitude of 0.0011 in. per in. for Zamak 2, 0.0008 in. per in. for Zamak 5 and 0.00067 in. per in. for Zamak 3 if heated in steam at 95°C for 3 hours. Thereafter the alloys begin expanding, Zamak 2 at a very fast rate but the rate decreases with time; Zamak 5 slowly, Zamak 3 slowly but the rate increases with time. The addition of traces of Ni to Zamak 3 prevents this increase in rate of expansion as time goes on. At 95°C in steam, Zamak 3N (Zamak 3 & Ni) has reached its original dimensions in 45 days, Zamak 5 in 60 days, Zamak 3 in 10 days, Zamak 2 in 2 days.

Corrosion.

A study of Fig. 4 shows that zinc base die

TABLE V (Page 9 - 10 Report No. 671/1)

Stability of A. S. T. M. Alloy XXI.

Zinc Base Die Casting with 2.5/3.5% Cu - 3.5/4.5% Al - 0.03/0.08% Mg

Location of Exposure	Tensile Strength 1000psi			Elongation %			Charpy ft. lbs.			Growth of 6 in. bar in x 10 ⁻⁴ /6 in.		
	Mx	Mn	Ave	Mx	Mn	Ave	Mx	Mn	Ave	Mx	Mn	Ave
				OUT OF DOORS *			5 years					
Key West, Fla.	51.0	46.5	49.6	1.0	0.2	0.5	1.50	0.75	1.1	107.	37.	76.
Sandy Hook, N.J.	55.9	46.1	49.5	3.9	2.3	3.2	3.50	3.00	2.8	32.	-1.	19.
Altoona, Pa.	52.0	45.5	48.1	2.6	1.4	1.8	3.0	1.75	2.3	28.	-5.	12.
New York, N. Y.	52.7	46.5	48.7	2.2	1.0	1.8	4.25	3.0	3.6	48.	0	21.
Rochester, N. Y.	56.5	46.1	51.6	3.1	2.3	2.8	-	-	-	-	-	-
State College, Pa.	54.8	47.4	50.8	2.2	0.5	1.1	5.0	1.75	2.6	29.	-9.	10.
				IN DOORS **			5 years					
Coco Solo	52.1	46.0	48.6	1.3	0.5	.8	1.75	1.25	1.50	98	46	74
Cambridge, Mass.	55.7	47.3	50.8	1.4	0.8	1.1	2.25	1.75	2.00	52	11	30
Hanover, N. Mex.	55.1	47.9	51.6	2.0	1.1	1.5	2.50	1.75	2.05	43	13	28
New Kensington, Pa.	54.8	48.3	51.8	2.2	1.8	2.0	1.50	1.25	1.40	74	20	53
				ORIGINAL VALUES								
	45.5 47.8			5.6			8.27					

* Average of data on alloys from 5 producers.

** Average of data on alloys from 4 producers.

Note: This shows loss of impact strength of alloy of particular composition which is not considered satisfactory for Ordnance purposes.

From A. S. T. M. Data 1935

castings do not suffer corrosion as much as when Ni is present as a protective coating. Nickel is cathodic to Zn and so would cause extensive galvanic corrosion to occur at any pinhole when exposed in a conducting electrotpe as the wet film of condensed NaCl spray would be. As shown on Table IV there is no exception to the fact that all properties of the Ni plated specimens were the lowest of all tested.

The Ni plate showed signs of failure after only 16 hours in the spray indicative of presence of pits. The Ni plate had similarly failed after 6 months atmospheric exposure.

The Dichromate film offered excellent protection standing up more than 150 hrs. in the salt spray. This film is relatively easy to apply. The grease free surface is cathodically cleaned in Na_3PO_4 solution, rinsed thoroughly and dipped in a solution containing $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$, 200 g./l. and H_2SO_4 (Sp.Gr.1.84) 6c.c./l. maintained at room temperature. The time of immersion is around 10 seconds. Too long immersion results in too thick a coating which is liable to crack and to be otherwise non adherent.

The suggested use of Cd plate is open to objection. Cd has a deleterious effect on zinc die castings hastening intergranular corrosion. If

too thin a Cd plate is applied, diffusion may occur over long periods of time especially if maintained at temperatures above normal room temperatures. This will facilitate undue growth of the casting. On the other hand if a poor die casting is coated with a thick film of Cd, the atmosphere cannot reach the casting which, thusly protected, is less liable in intergranular corrosion and growth. Cadmium is more resistant to salt spray than zinc, the latter forming a powdery film of basic chloride, whereas the former tends to stay clean.

It is believed that the dichromate film will be a suitable substitute for Cd plate. Ni plate is not to be recommended for long time protection against severe corrosion.

Zinc-base die castings for Bouchons.

The test bouchons supplied were found to expand too much for good material. Information supplied was that the analysis was satisfactory. Further tests were made but it was not till the spectroscopic facilities were available that the high percentage of Cd was detected. The bouchon did not appear to be coated with Cd so it was concluded that the Cd was actually an impurity. If the bouchons were originally Cd plate, then the Cd has diffused into the base metal. It is,

therefore, necessary to be extra careful when accepting zinc base die cast products.

It appears that any change in dimensions of bouchons within manufacturing limits will be without effect on its functioning. At time of use the bouchon is subject to impact stresses especially at the hinge holding the firing pin in place. As zinc base die castings containing $2\frac{1}{2}\%$ Cu and 4% Al are liable to growth greater than machining tolerances and at the same time lose in ductility, and in impact values, it does not appear logical to use this alloy. The alloy containing no Cu and 4% Al would be a better choice.

The bouchons under test by Picatinny Arsenal are, therefore, expected to fail. If no failure occurs, it means that conditions of use do not tax the metal to its limit. If it does fail, then careful check up should be made to determine if it is lack of tensile strength, lack of ductility excessive growth or simple corrosion which is at fault. If failure does occur, it does not mean that die castings are unsuitable as a whole, it may and probably will mean only that aluminum containing zinc base die castings with $2\frac{1}{2}\%$ Cu are not satisfactory especially if too much impurity is present.

Commercial Uses.

Commercial Uses include the following: Tripod head, lubricator bodies, base and traveling arms of machines, automatic oil hose coupling, bodies for pneumatic hand files, hand chippers and hand grinders, lighting fixtures, small motor & gear cases, mechanical toys, motor housings, rotor winding, brake arm, idler gear, gear frames, shaft frames, gears & worms, door check, golf club heads, radiator frames & caps, windshield frame, carburetors, typewriter and check writer parts, washing-machine frames, drain faucets, plumbing, hardware, garden hose nozzles, calibrated wheels, vacuum cleaner frames and other parts.

It is believed that die castings can be profitably used by the Ordnance Department for those parts whose dimensional tolerances are nominal and which are required in great quantities.

It is apparent that U. S. Army Specification No. 57-93-A is old. This specification permits the Army being supplied with alloys so rich in Pb, Cd, and/or Sn as to be subject to rapid aging. The variations in major constituents are too wide for good practice. It has been shown that the alloy corresponding to Cl is not as desirable as others now available. No particular benefit is to be obtained from using an alloy with 1% Cu that is not

available from alloys corresponding to Zamak 3 or 3N Specification WXS8 has been drawn up embodying the recommendations arrived at in this study. Two grades were recommended. Grade A with 3.5/4.3% Al, 0.10 max Cu .03/.08% Mg and Grade B, similar plus 0.015/0.05% Ni.

Summary

A study was made of the physical properties and changes that occur of available zinc base die castings. That alloy with 2.5/3.5% Cu, the strongest, changed the most, whereas one with no copper changed the least. That alloy with 1% Cu lost in impact values more than the one without copper. The new alloy with small amounts of Ni appears to be promising as the best alloy available, but lack of normal aging data should properly delay its wholesale adoption until such data becomes available and confidence in it increases. Sufficient data is back of alloy corresponding to A.S.T.M. XXIII, SAE 903, Zamak 3, or Grade A (Spec. WXS8) to justify its use for long periods in place of alloy corresponding to A.S.T.M. XXI, SAE 921, Zamak 2 now widely used. Data is summarized on Table VI indicative of the aging characteristics of zinc base die castings.

TABLE VI

Summary of Data on Stability of Zinc-base Die Castings.

		N.J. Zn Co. Zamak 2, ASTM 21	W. A. Test Zamak 2	ASTM Specifi- cation Ave of 5 specimens	N.J. Zn Co Zamak 3 ASTM 23	W. A. Test Zamak 3	ASTM Specifi- cation Ave of 5 specimens	ASTM Information Zamak 3N	W. A. Test Zamak 3N	N.J. Zn Co. Zamak 5	W. A. Test Zamak 5
Tensile Strength 1000 psi	Original	47.3	46.9	44.0	36.8	37.5	35.0	41.7	36.9	41.6	41.2
	10 dy steam 95°C	45.1	42.0	30.0	33.0	33.1	30.0	33.6	32.5	35.2	35.9
	1 yr dry 95°C	39.0	-	-	31.1	-	-	31.1	-	33.4	-
	2 yr dry 95°C	38.8	-	-	29.8	-	-	-	-	32.1	-
	1 yr indoor	47.8	-	-	35.9	-	-	-	-	40.8	-
	3 yr indoor	48.9	-	-	33.3	-	-	-	-	38.8	-
	1 yr outdoor Key West	47.2	-	-	-	-	-	-	-	-	-
Impact ft lbs 1/4" Section	Original	15.0	11.9	6	20.0	13.5	12	22.5	7.2	17.8	15.6
	10 dy steam 95°C	1.5	0.6	.75	19.0	13.4	12	20.5	7.6	10.3	6.5
	1 yr steam 95°C	0.3	-	-	0.	-	-	4.5	-	0.6	-
	1 yr dry 95°C	1.25	-	-	21.5	-	-	30.	-	4.0	-
	2 yr dry 95°C	1.25	-	-	16.5	-	-	-	-	3.5	-
	1 yr indoor	12.75	-	-	20.35	-	-	29.0	-	17.5	-
	3 yr indoor	6.0	-	-	19.8	-	-	-	-	17.5	-
	1 yr outdoor Key West	2.8	-	-	-	-	-	-	-	-	-
Expansion in per in x 10 ⁻⁴	10 dy steam 95°C	19.7	18.4	25.	7.2	1.0	10.0	3.0	2.5	3.0	1.1
	1 yr steam 95°C	50.*	-	-	166.*	-	-	75.	-	50.	-
	1 yr dry 95°C	35.3	-	-	1.7	-	-	2.3	-	7.7	-
	2 yr dry 95°C	35.8	-	-	2.0	-	-	-	-	9.7	-
	1 yr indoor Coco Solo	1.2	-	-	-	-	-	-	-	-	-
	1 yr indoor	-0.5	-	-	-0.7	-	-	0.3	-	-1.3	-
	3 yr indoor	3.7	-	-	-1.0	-	-	-	-	-1.3	-
	1 yr outdoor Key West	1.2	-	-	-	-	-	-	-	-	-

* Estimated

On the basis of this study Specification WXS8
has been suggested covering die castings for Ordnance
use.

Respectfully submitted,

Peter R. Kosting

APPENDIX I

REPORT NO. 671/1

Information supplied by the New Jersey Zinc Co. regarding their analyses of samples of bouchons supplied by Picatinny Arsenal (W. A. 470.1/3415) is that the Lead content is definitely less than 0.018% and probably less than 0.01%, and Cadmium, nearly 1%.

Since the specimens failed in the steam test, and since the Lead content apparently is not unduly high and the absence of Tin is clearly established, it seems probable that some Cadmium was present in the alloy to account for the failure of the steam test.

The New Jersey Zinc Co. reports that the use of Cadmium plate on Zinc base die castings is safe practice. They have not observed any diffusion of Cadmium occurring at temperatures lower than the oxidizing temperature.

CORRECTIONS
REPORT NO. 671/1
WATERTOWN ARSENAL
ZINC BASE DIE CASTINGS

Page 1, Conclusions, par. 4, line 2, add:

"Lead and tin are also dangerous impurities."

Page 2, par. 2, line 2, after "0.03/0.08% Mg", add:

"and balance high purity Zn"

Page 4, par. 1, line 3; par. 1, line 7; par. 2, line 3;

change: "delta" to "gamma"

Table I, change % Cu, N. J. Zinc Co. Zamak 2 to:

"2.5/2.9"

change % Al. A.S.T.M. Preprint 183, 1934

Alloy XXIII to:

"3.5"
4.3

change % Mg N. J. Zinc Co. Zamak 3 to:

"0.03"
0.06

add exponent "3" in row entitled, "Zinc" under
columns headed, "Zamak 2", "Zamak 3", and
"Zamak 3N"

Page 7, par. 2, line 6, after "pass", add:

"A.S.T.M."

after "specifications", add:

"because this alloy average only 7 ft. lbs.
impact against specification limit of 12
average and 8 individual minimum".

Page 8, par. 3, line 9, after "expanded", add:

"in the order of magnitude of 1×10^{-3} "

In place of the sentence beginning "This" and
ending, "tropics", add:

"One day in the steam bath is usually considered
the equivalent of one year's normal use in the
tropics."

Page 9, par. 3, line 6, after "heated in", add:

"dry air or in"

after "thereafter", add:

"in steam"

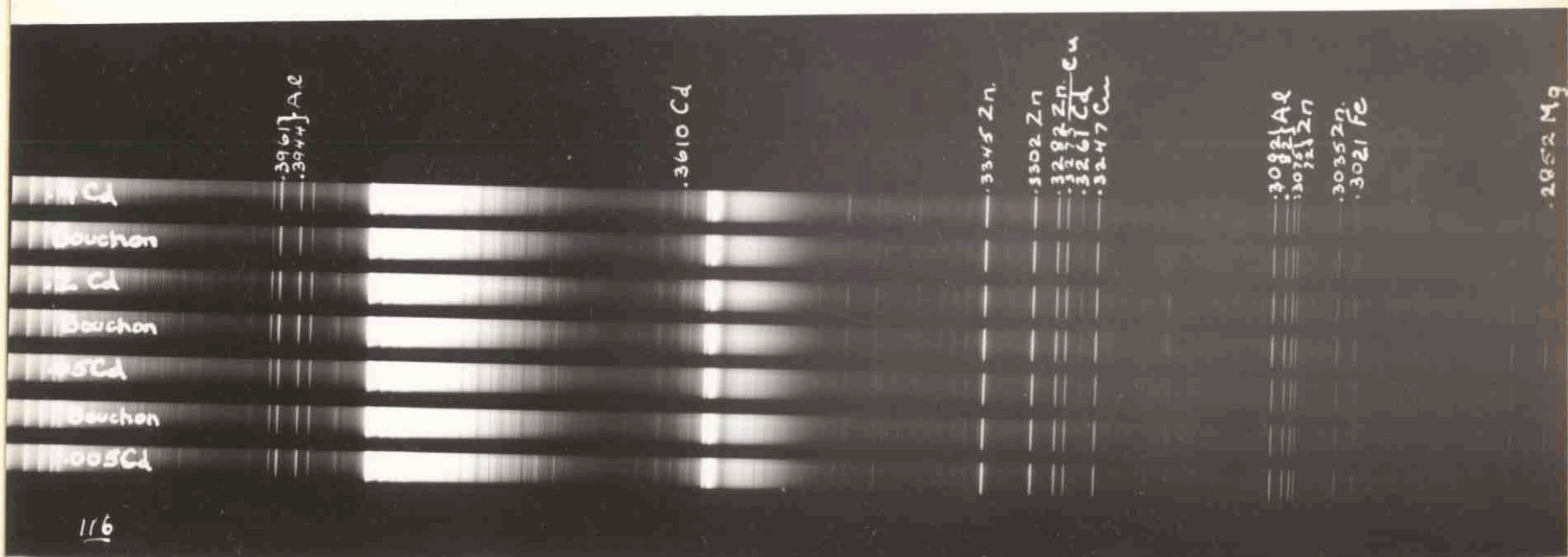
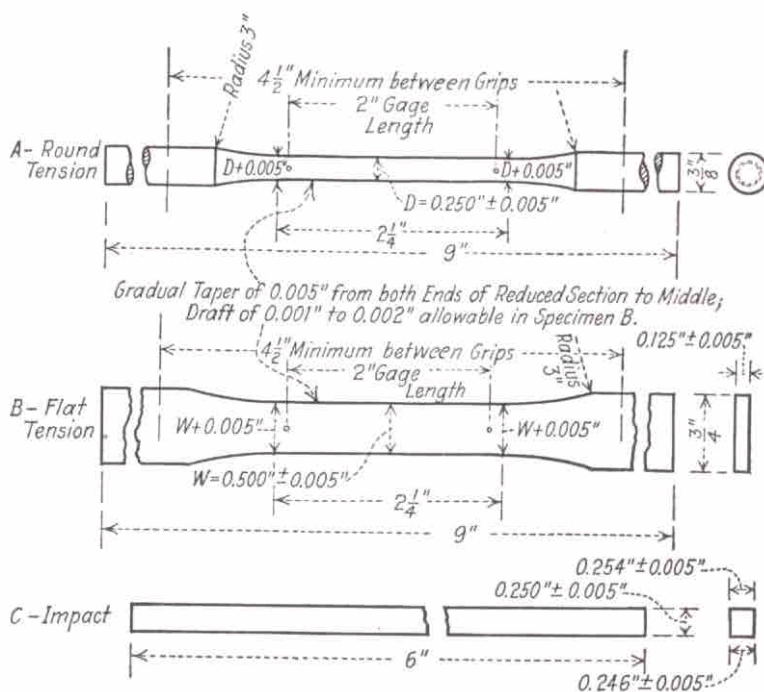


Fig. 1

Spectrographic examination of Zinc base Die cast Bouchons

ON DIE-CAST METALS AND ALLOYS



The three Specimens shown to be cast in Die Plate, parallel to each other at 2" Center to Center.

Specimens to be gated at one End (on Midline of Center Specimen); no Ejector Pins on Reduced Sections; Pin Marks on Ends to be flush or low.

Specimens to be removed from Dies as soon as cast, cooled-adjacent in Wooden Box with Gates attached.

Gates to be sawed off before Shipment but Fins to be removed in Testing Laboratory.

Each Specimen to be marked with Number of Alloy, Roman Numerals (I to XII) and Initials of Manufacturer (Insert) and tagged with Date of Casting.

Specimens A and B for Tension and C for Izod or Charpy Impact. Hardness Tests to be made on Ends of Specimen-B using Rockwell Scale "E" ($\frac{1}{8}$ " Ball, 100 Kg. Load, Red Figures). Test on $\frac{3}{16}$ " Diam. Anvil; remove Major Load as soon as fully applied.

Low Capacity Impact Machines of type suitable for Die Casting Tests are described in A.S.T.M. Proc. 1926, II 634 f.f.

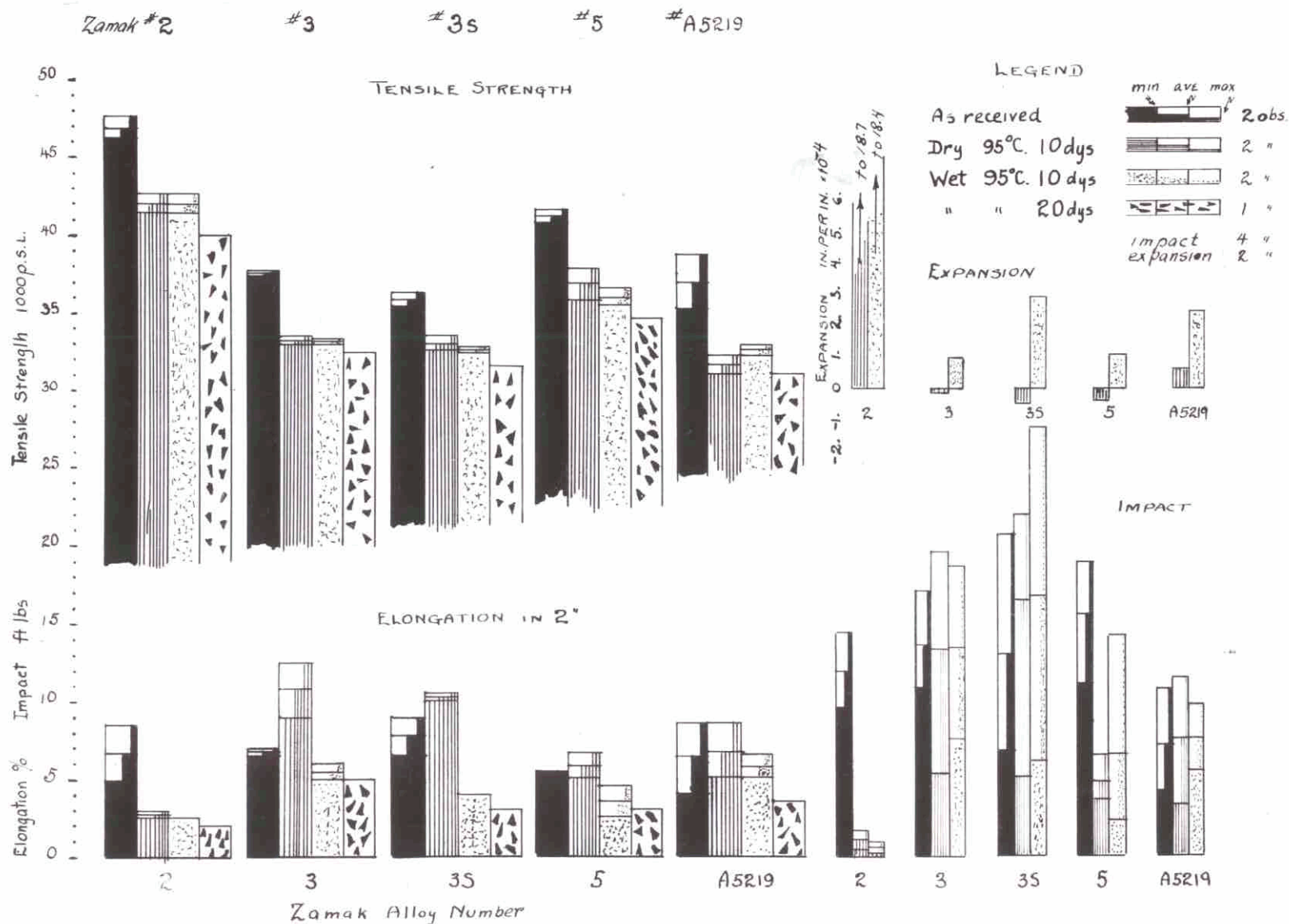
Minimum Number of Specimens to be tested: Tension and Impact, 5 of each Type; Rockwell, 3 Readings on each Flat Specimen. Report Rockwell Readings for Gate (thick Fin) and vent Ends separately.

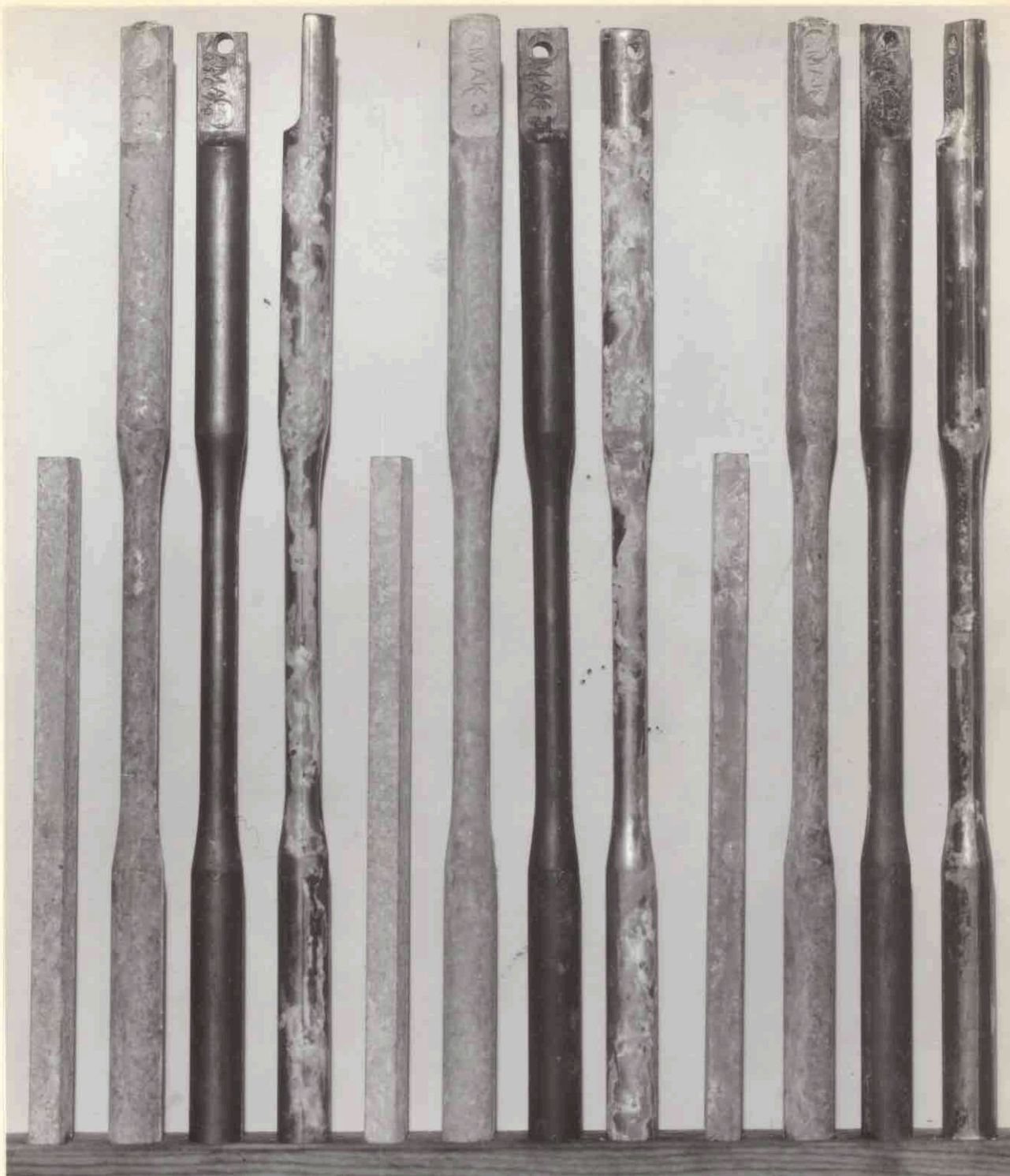
TABLE III

Change in properties of Zinc Die Castings

Zamak Alloy		Tensile Strength 1000psi				Elongation in 2" %				Impact 1/4" section ft lbs				Expansion in/in		
		As rec'd	Dry 95°C	Wet-10 95°C	Wet-20	As rec'd	Dry 95°C	Wet-10 95°C	Wet-20	As rec'd	Dry 95°C	Wet-10 95°C	Dry 95°C	Wet 95°C	Rm Temp 103 dys	
2	mx	47.6	42.6	42.6	x	8.5	3.0	2.5	x	14.2	1.6	0.97	+18.7x10 ⁻⁴	+18.4x10 ⁻⁴	-2.5x10 ⁻⁴	
	mn	46.2	41.4	41.4	x	5.0	2.5	2.5	x	9.4	0.3	0.25				
	Ave	46.9	42.0	42.0	40.0	6.8	2.8	2.5	2.0	11.9	1.0	0.63				
	% Δ	-	-10.	-10.	-15.	-	-59.	-63.	-71.	-	-92.	-95.				
3	mx	37.6	33.4	33.2	x	7.0	12.5	6.0	x	17.0	19.4	18.6	-0.25x10 ⁻⁴	+1.0x10 ⁻⁴	-1.5x10 ⁻⁴	
	mn	37.4	33.0	33.0	x	6.5	9.0	5.0	x	10.8	5.3	7.4				
	Ave	37.5	33.2	33.1	32.4	6.8	10.8	5.5	5.0	13.5	13.3	13.4				
	% Δ	-	-11.	-12.	-14.	-	+59.	-19.	-26.	-	-1.5	-0.7				
3S	mx	36.2	33.4	32.8	x	9.0	10.5	4.0	x	20.5	21.9	27.3	-0.5x10 ⁻⁴	+2.9x10 ⁻⁴	-0.9x10 ⁻⁴	
	mn	35.4	32.6	32.6	x	6.5	10.0	4.0	x	6.8	5.1	6.1				
	Ave	35.8	33.0	32.7	31.6	7.8	10.3	4.0	3.0	12.9	16.4	16.7				
	% Δ	-	-7.8	-8.6	-12.	-	+32.	-49.	-62.	-	+27.	+29.				
5	mx	41.6	37.8	35.4	x	5.5	6.5	4.5	x	18.9	6.4	14.2	-0.4x10 ⁻⁴	+1.1x10 ⁻⁴	-1.0x10 ⁻⁴	
	mn	40.8	35.8	36.4	x	5.5	5.0	2.5	x	11.1	3.6	2.3				
	Ave	41.2	36.8	35.9	34.6	5.5	5.8	3.5	3.0	15.6	4.8	6.5				
	% Δ	-	-11.	-13.	-16.	-	+ 5.5	-36.	-45.	-	-69.	-58.				
A5219	mx	38.6	32.2	32.8	x	8.5	8.5	6.5	x	10.8	11.5	9.8	+0.67x10 ⁻⁴	+2.5x10 ⁻⁴	-0.9x10 ⁻⁴	
	mn	35.2	31.0	32.2	x	4.0	5.0	5.0	x	4.2	3.3	5.3				
	Ave	36.9	31.6	32.5	31.0	6.3	6.7	5.7	3.5	7.2	7.6	7.6				
	% Δ	-	-14.	-12.	-16.	-	+6.	-10.	-44.	-	+6.	+6.				

Fig.3- PROPERTIES OF ZINC DIE-CASTINGS TESTED AT WATERTOWN ARSENAL





A B C
ZAMAC 5

A B C
ZAMAC 3

A B C
ZAMAC 2

FIG. 4
APPEARANCE OF TEST BARS AFTER CORROSION IN SALT SPRAY
A- NO COATING B- DICHROMATE FILM C- 0.001" NI PLATE

N.A. 362-33

FIG. 5A - CHANGE IN PROPERTIES OF ZINC BASE DIE CASTINGS.

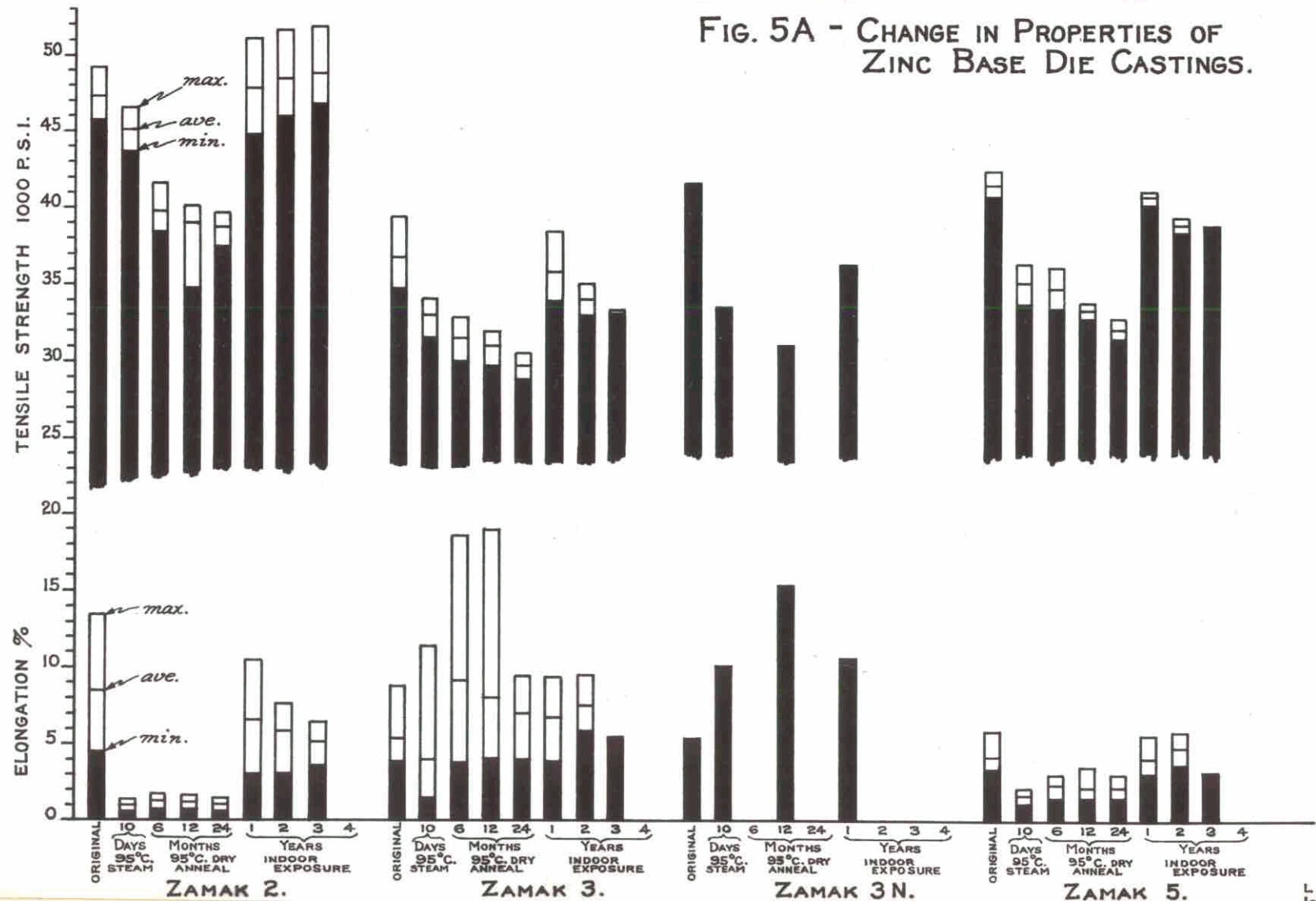


FIG. 5B - CHANGE IN PROPERTIES OF ZINC BASE DIE CASTINGS.

